High Resolution Plasmaphere Observatory Development

Completed Technology Project (2018 - 2021)

Project Introduction

Science Goal. The science goal of this proposal is to determine the system-level evolution of fine-scale (0.05 Earth radii, RE) density structure of the Earth's plasmasphere on 1 to 2 minute time scales. Fine-scale cold plasma structure can exert a critical influence on wave and particle dynamics of the magnetosphere and ionosphere. Method. To achieve the project science goal, we propose to develop the High Resolution Plasmasphere Observatory (HRPO), a prototype wide-field extreme ultraviolet (EUV) camera with order-of-magnitude improved spatial and temporal resolution compared to any previously flown plasmasphere imager. The IMAGE EUV imager featured a large (~30 degrees) field-of-view, but a relatively poor (~0.6 degrees) spatial resolution. IMAGE EUV was limited by a detector obscuring most of the entrance aperture (reducing throughput and design flexibility). IMAGE EUV included a spherical-surface detector that was expensive and difficult to manufacture. Improvements in reflective coatings, optical surface manufacturing, and detector sensitivity allow for a new two-mirror off-axis optical design with a flat focal surface. The prototype imager [Davis et al., 2014, Proc SPIE, doi:10.1117/12.2057020] will be built, aligned, calibrated, and environmentally tested over a three-year period, raising the TRL from 2 (software design) to 5 (prototype through environmental testing). There are two main driving requirements of this instrument development: (1) angular resolution less than or equal to 0.36 degrees, needed to resolve 0.05 RE structure (from a notional 8 RE orbit), and (2) effective area at or above 0.5 square cm, needed to observe tenuous fine structure with a 1 to 2 min image cadence. It is also important (but not a driving requirement) to maximize the camera field of view. There is significant margin in the HRPO software design, which has 0.07 degree angular resolution (factor of 5 better than required, and 9 times better than IMAGE EUV) and effective area 1.2 square cm (factor of 2.4 better than required, and 4 times better than IMAGE). The average margin on performance of individual camera elements (multilayer mirror, filter, and detector) is 20%. Work Plan. The objective of the proposed project is to advance the TRL of the prototype EUV imager from 2 to 5. The first year will be spent finalizing the optical design and procuring optics. Both primary and secondary mirrors are aspheric, so a year is an appropriate amount of time to spend in their design and fabrication. The second year will be spent applying a multilayer coating so that the mirrors reject 58.4 and 121.6 nm background light (corresponding to neutral He and H emissions) while reflecting 30.4 nm (He+ emission) signal light. The coating work will be followed by construction of a brassboard instrument utilizing the new optics and in-house EUV-sensitive detectors. The third year will be spent calibrating the system and environmentally testing the brassboard instrument over expected vibrational launch loads and operational thermal extremes. At the end of Year 3 we formulate a detailed plan to get from TRL 5 to TRL 6. Importance, Relevance to NASA. The plasmasphere holds most of the mass/inertia of the magnetosphere. It is of central importance in geospace, and highly relevant to the NASA SMD Science Plan and the Heliophysics

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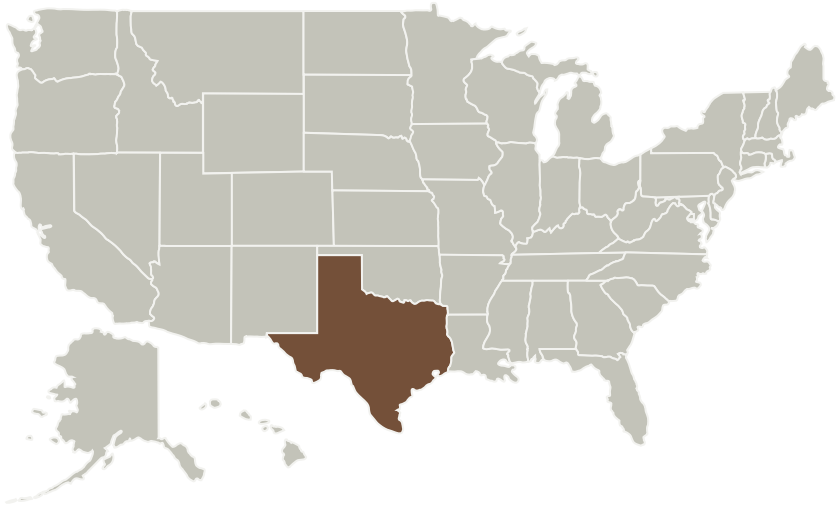
Decadal Survey. A next-generation, state-of-the-art EUV camera advances the type of science that can be done with plasmaspheric imaging, by making system-level observation of cross-scale plasma structure a reality. The Decadal Survey's highest ranked new magnetospheric mission concept, MEDICI, requires an EUV camera with the same minimum requirements for spatial/temporal resolution (0.05 RE, 1 min) as HRPO. This ITD is an invaluable opportunity to qualify HRPO: an EUV camera that meets/exceeds relevant Decadal Survey requirements, and fills the need for high-resolution, system-level plasmaspheric imaging.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Southwest Research Institute - San Antonio(SWRI)	Lead Organization	Academia	San Antonio, Texas

Primary U.S. Work Locations
Texas

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Southwest Research Institute - San Antonio (SWRI)

Responsible Program:

Heliophysics Technology and Instrument Development for Science

Project Management

Program Director:

Roshanak Hakimzadeh

Program Manager:

Roshanak Hakimzadeh

Principal Investigator:

Jerry Goldstein

Co-Investigators:

Ronald B Kalmbach
Philippa M Molyneux
Michael W Davis

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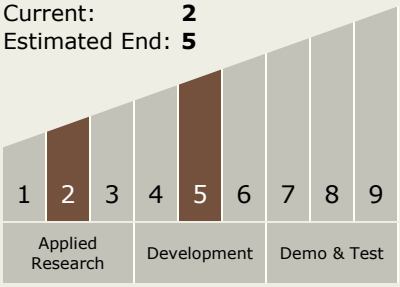
Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **5**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

The Sun